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Environmental Ethics in Social Media-Based Sustainability Research: From Cultural Ecosystem Services to Digital Environmental Governance: A Literature Review

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ABSTRACT

Social media data have become a major empirical resource for examining how people perceive, value, discuss, contest, and govern environmental change. This literature review synthesizes recent scholarship on cultural ecosystem services, environmental communication, biodiversity monitoring, built-environment studies, and sustainability governance. It argues that environmental ethics should become the organizing framework of social media-based environmental research. Recent studies show rapid methodological expansion through natural language processing, computer vision, multimodal fusion, geospatial analytics, transformer models, reinforcement learning, and generative AI, enabling increasingly fine-grained analyses of human-environment relations (Schirpke et al., 2023; Yang et al., 2025; Ghermandi et al., 2026). At the same time, these advances amplify ethical concerns around representation, demographic bias, privacy, consent, interpretability, intervention, platform instability, and unequal access to environmental benefits and participation (Oguro & Shibata, 2025; Otero et al., 2025; Chandana et al., 2025; Fox et al., 2025). Across domains, the literature consistently shows that digital traces are not neutral mirrors of environmental reality; rather, they are selective, culturally mediated, and normatively charged signals that can either reproduce or challenge existing inequities. This review therefore proposes an environmental-ethics agenda centered on epistemic justice, relational valuation, responsible automation, and governance-ready transparency. It concludes that the future of this field depends less on harvesting more data than on designing ethically reflexive, multimethod, and publicly accountable research infrastructures capable of supporting just and ecologically meaningful decision-making.

Keywords: Environmental ethics; social media analytics; cultural ecosystem services; environmental communication; sustainability governance; digital environmental justice; AI for sustainability

INTRODUCTION

The environmental turn in digital research is no longer confined to communication studies or computational social science. Social media data now inform analyses of cultural ecosystem services (CES), biodiversity monitoring, urban environmental perception, crisis communication, consumer protection, green branding, environmental disclosure, and social responses to climate risks (Dagan

& Wilkins, 2023; Dubey et al., 2024; Singh et al., 2025; Spaiser, 2025). What initially appeared to be a methodological innovation—a cheap, scalable source of geo-tagged texts, images, videos, reviews, and interactions—has become a substantive reorientation of environmental knowledge production. Researchers increasingly treat digital traces not only as proxies of visitation or sentiment, but as situated records of meaning making, affect, care, conflict, and governance in relation to ecosystems, landscapes, and environmental issues (Calcagni et al., 2023; Ashayeri, 2024; Ghermandi et al., 2026).

This expansion has been especially visible in CES research, where social media has opened "digital windows" into otherwise difficult-to-measure non-material values such as aesthetics, spirituality, inspiration, identity, memory, and recreation (Calcagni et al., 2023; Comalada et al., 2025; Ghermandi et al., 2026; Wang et al., 2026). Yet the same literature also shows that digital mediation is not merely an instrument for observing values. Platforms actively shape what kinds of environmental relationships become visible, whose experiences are amplified, what emotions are classified, and which landscapes are rendered legible to planning and management. Studies of urban parks, traditional villages, forests, freshwater ecosystems, coastal cities, and rural tourism repeatedly find that the social media record is structured by platform affordances, user demographics, posting cultures, algorithmic visibility, and data access regimes (Chen et al., 2024; Oguro & Shibata, 2025; Yang et al., 2025; Ghermandi et al., 2026).

For that reason, the central question is no longer whether social media can help environmental research. The more pressing question is what kind of environmental knowledge is being generated, for whom, under what ethical assumptions, and with what consequences. Recent work on privacy, platform ethics, responsible AI, misinformation, intervention systems, and data security suggests that environmental research using social media can no longer treat ethics as a downstream compliance exercise (Chandana et al., 2025; Fox et al., 2025; Upadhyaya et al., 2025; Otero et al., 2025). Environmental ethics is now integral to methodological design because the objects of study—human–nature relations, vulnerability, environmental benefits, and public discourse—are inherently normative. This is particularly clear when social media data are used to infer inequitable access to urban green space, to monitor species and marine wildlife, to simulate responses to environmental messaging, or to intervene in public online discourse (Nascimento et al., 2024; Cao et al., 2026; Neri et al., 2026).

LITERATURE REVIEW

The evolution of social media–based environmental research

The foundational phase of this field emphasized proof of concept. Early and synthetic contributions showed that large, secondary, and crowdsourced datasets could complement surveys and official statistics in outdoor recreation and ecosystem-service research, while geospatial technologies and digital data infrastructures broadened the operational reach of sustainability studies (Depietri et al., 2023; Dagan & Wilkins, 2023; Schirpke et al., 2023). These works established three enduring claims. First, digital trace data are scalable and comparatively low cost. Second, they can reveal temporal and spatial variation at resolutions that traditional methods often miss. Third, they are especially useful for non-market and non-material phenomena that are difficult to capture through administrative records alone (Ghermandi & Sinclair, 2024; Schirpke et al., 2023).

The second phase centered on diversification. Researchers moved beyond single-platform analyses of visitation and began exploring perceptions, emotions, narratives, and value pluralism across images, text, reviews, and hybrid datasets (Chai-allah et al., 2023; Ashayeri, 2024; Chen et al., 2024). In parallel, environmental communication scholars widened the thematic scope from climate change to

planetary boundaries, green brands, environmental discourse, crisis messaging, and corporate disclosure, showing that environmental meanings on social media are distributed across communities, sectors, and communicative genres rather than concentrated in a single issue arena (Dubey et al., 2024; Pimonenko et al., 2025; Salley et al., 2025; Zhang & Xiang, 2024). Sustainability research likewise expanded the field's ambition, examining how social media supports campaigns, crowdsourcing, collaboration, behavior change, and governance-oriented sustainability practices (Singh et al., 2025; Purushottam & Matli, 2025; Zarrabeitia-Bilbao et al., 2025).

A third phase is now emerging in which the field is becoming both more powerful and more reflexive. Systematic reviews in CES, built environment, sustainability communication, and computational social science no longer ask only what social media can reveal; they also ask how changing platforms, multimodal AI, data inequality, and contextual variability alter the epistemic conditions of research (Yang et al., 2025; Ghermandi et al., 2026). Several reviews note that the same data source can be celebrated as democratizing and criticized as exclusionary, depending on whether one prioritizes scale, interpretive richness, representativeness, or accountability (Schirpke et al., 2023; Otero et al., 2025; Ghermandi et al., 2026). This ambivalence is not a weakness of the literature. Rather, it signals the maturation of a field that increasingly understands digital traces as socio-technical artifacts embedded in power-laden infrastructures.

The most recent studies push this maturation further by connecting environmental perception to environmental justice, relational values, and ethics of intervention. Work on unequal access to CES in Rome and Broward County, on nature-relatedness and eco-friendly behavior on Instagram, on energy justice inferred from sentiments, and on environmentally responsible discourse intervention all suggest that the empirical and normative dimensions of digital environmental research are now inseparable (Ashayeri & Abbasabadi, 2024; Upadhyaya et al., 2025; Cao et al., 2026). In other words, the field has moved from "can social media measure environmental experience?" to "how should digital environmental knowledge be ethically produced and responsibly used?"

Table 1. Representative trajectories in social media–based environmental research

Domain	Typical data source	Analytic approach	Main contribution	Key ethical concern	Ref.
CES synthesis	Multi-platform social media studies	Systematic review and conceptual synthesis	Consolidates 218 CES studies and clarifies conceptual fragmentation	Platform dependence and definitional incoherence	Ghermandi et al. (2026)
Ecosystem-service assessment	Mixed emerging technologies	Review of technological opportunities	Connects AI, mobile, web, and geospatial tools to ES assessment	Accessibility and meaningful inclusion	Schirpke et al. (2023)
Built environment	Crowdsourced urban data	PRISMA review	Shows contextual variability in crowdsourced urban research	Cultural bias and interpretive transferability	Yang et al. (2025)
Sustainability communication	Multi-platform sustainability campaigns	Survey review	Classifies six social-media strategies for sustainability action	Authenticity, fatigue, and misinformation	Singh et al. (2025)
Environmental communication	Twitter/X discourse	Network analysis and topic modeling	Demonstrates broad but uneven environmental	Global North bias and issue invisibility	Dubey et al. (2024)

			discourse beyond climate		
Computational sustainability	Cross-domain digital traces	Conceptual review	Frames computational methods as tools for ecological justice	Governance of generative AI and political effects	Spaiser (2025)

What the new literature adds: methods, media, and multimodality

Recent literature is distinguished less by a single methodological breakthrough than by the convergence of multiple analytic pipelines. Machine learning, transformer-based natural language processing, semantic segmentation, topic modeling, social network analysis, explainable AI, and multimodal fusion are increasingly used in combination rather than isolation (Ashayeri & Abbasabadi, 2024; Fildisi et al., 2025; Upadhyaya et al., 2025). This matters because environmental meanings are now studied as composite phenomena: images capture scenic composition, text registers sentiment and narrative framing, metadata supplies time and place, and interaction networks reveal circulation and amplification. Such integration makes social media research more analytically powerful, but it also increases the opacity and normative stakes of inference.

Computer vision has become central in landscape, park, and biodiversity studies. Studies of seasonal forests, traditional villages, and traditional built environments use segmentation, depth estimation, and explainable machine learning to identify which visual elements correlate with positive emotions or perceived environmental quality (Chen et al., 2024; Chen et al., 2024; Ding et al., 2025). Reviews of image-based urban studies likewise show that deep learning has rapidly expanded, although often without consistent standards for training data, transferability, or interpretation (Su et al., 2025). In CES research, automatic image analysis has also been used to compare aesthetic appreciation across differently managed grasslands, linking biodiversity-rich visual features to cultural value recognition (Klaus et al., 2025). These approaches extend environmental perception research, but they also risk reifying aesthetic preference as if it were culturally universal when it is often highly situated.

Text analytics has become equally prominent. Georeferenced text from Twitter/X, online reviews, trip reports, and platform-specific postings is now used to map CES, infer emotional dynamics, identify thematic clusters, and evaluate environmental messaging (Derrien et al., 2024; Salley et al., 2025; Liu et al., 2026). Topic models and sentiment classifiers have been applied to urban parks, environmental crises, flood communication, and country green-brand narratives, showing that large-scale text data can reveal not only whether people are talking about the environment but how they appraise risk, care, quality, and justice (Ashayeri, 2024; Pimonenko et al., 2025; Salley et al., 2025; Liu et al., 2026). Importantly, newer work moves beyond binary polarity. Studies distinguish anger from anxiety and sadness, compare organizational versus community messaging, and examine how platform-specific discourse shapes environmental attention and polarization (Dubey et al., 2024; Salley et al., 2025; Liu et al., 2026). This is a major methodological advance because environmental governance depends not just on aggregate sentiment but on differentiated emotional and interpretive structures.

Multimodal modeling is the newest frontier. The built-environment and park-perception literatures increasingly combine image data with user review texts, pre-training strategies, and reinforcement learning to improve classification and generalization across park types (Chen et al., 2025; Yang et al., 2025). Biodiversity researchers likewise point to the value of combining text, images, video, and spatio-temporal metadata in social

media to detect species occurrences, human–wildlife interactions, or conservation issues with greater sensitivity than single-modality approaches (Fox et al., 2025; Neri et al., 2026). The significance of this development is ethical as well as technical. Multimodality can reduce the blind spots of any one data form, but it can also increase surveillance potential, intensify re-identification risks, and blur the boundaries between scientific observation and extraction from publics who did not produce content for research purposes (Fox et al., 2025; Chandana et al., 2025).

At the same time, the literature shows a decisive movement toward explainability and intervention. Explainable frameworks such as SHAP are used to trace how environmental features influence sentiment, while interpretable stance detection models explicitly separate rationale generation from classification (Chen et al., 2024; Chen et al., 2024; Upadhyaya et al., 2025). In disaster and crisis contexts, the goal is increasingly to enable more responsive communication rather than only retrospective analysis (Abid et al., 2024; Salley et al., 2025). Yet interpretable systems do not eliminate ethical concerns. Instead, they shift them: once models can be explained and operationalized, the question becomes who decides what kinds of communication should be nudged, corrected, or filtered, and according to which environmental and democratic values.

MATERIALS & METHODS

This review develops a synthetic argument that environmental ethics provides the most coherent framework for integrating the field's methodological advances, domain diversification, and governance ambitions. The review synthesizes scholarship published mainly from 2023 to 2026 across cultural ecosystem services, biodiversity monitoring, built-environment analytics, environmental communication, and sustainability governance. Rather than treating ethics as a separate limitations section, this review uses ethical reasoning to structure how data are selected, how values are interpreted, how models are validated, how outputs are communicated, and how recommendations are translated into policy.

RESULT

Application domains and substantive insights

The richest and most cohesive body of work concerns CES. Recent studies confirm that social media is particularly valuable for examining aesthetics, recreation, inspiration, spirituality, and sense of place across diverse socio-ecological contexts (Ghermandi & Sinclair, 2024; Degano et al., 2025; Li et al., 2026; Wang et al., 2026). These studies also move the field beyond simple visitation counts. They reveal how values vary by habitat, time of day, user type, residency status, landscape composition, and biophysical setting (Calcagni et al., 2023; Degano et al., 2025; Li et al., 2026). For example, contemplative and spiritual values may cluster in less frequented areas, while recreational and aesthetic services may be emphasized by opinion leaders or high-visibility users, suggesting that digital value distributions are co-produced by ecological contexts and media ecologies rather than reducible to one or the other (Calcagni et al., 2023; Li et al., 2026; Wang et al., 2026).

A second important insight is that CES research increasingly links social media outputs to planning and management. Studies on urban green spaces, freshwater basins, nature parks, and agricultural landscapes translate digital traces into accessibility analyses, CES bundles, predictors of cultural benefits, or actionable recommendations for restoration and park management (Benati et al., 2024; Comalada et al., 2025; Depietri et al., 2025; Cao et al., 2026). This practical turn is one reason environmental ethics becomes indispensable: once digital traces are used to justify resource allocation, restoration priorities, or accessibility interventions, any bias in the data is no longer merely academic. It becomes distributive and political.

Recent CES work also underscores the importance of relational and non-material values that exceed standardized ecosystem-

service categories. Studies at Mount Kilimanjaro, in rural landscapes around Dianshan Lake, and in Helsinki's urban forests identify sense of achievement, affective and sensory experiences, iconic-place attachments, and motivations as key drivers or dimensions of environmental benefit (Degano et al., 2025; Li et al., 2026; Wang et al., 2026). This literature broadens the value vocabulary of environmental assessment and suggests that ethically robust research should avoid reducing environmental good to a narrow set of observable recreational markers. The ethical question is not only whether researchers can classify values accurately, but whether the classificatory system itself respects the plurality of human–nature relations.

Biodiversity, monitoring, and passive citizen science

Another major application domain concerns biodiversity monitoring and passive citizen science. Studies on jellyfish, bats, marine wildlife, diving pressure, and human-sensed environmental monitoring show that spontaneous online postings can generate ecologically relevant observations at scales difficult to achieve through conventional monitoring alone (Nascimento et al., 2024; Hunter et al., 2024; Mole & Noche, 2025; Neri et al., 2026). Reviews of passive citizen science in ecology argue that social media can complement traditional citizen-science programs by capturing opportunistic observations, broader public participation, and near-real-time signals (Otero et al., 2025). At the same time, AI-oriented reviews in biodiversity research highlight the value of multimodal approaches for detecting invasive species, distribution shifts, or biodiversity events, particularly when computer vision and NLP are integrated (Fox et al., 2025).

The conservation promise is substantial, but so are the risks. Citizen-sourced biodiversity data can reveal sensitive locations, enable misuse, and expose conservation targets to greater pressure, especially in an era of open-source software and increasingly powerful AI tools (Fox et al., 2025). Marine and wildlife studies also show how platform users are not merely observers but participants whose own practices—such as proximity to wildlife during diving—become ethically salient (Neri et al., 2026). In this sense, social media–based monitoring should not be understood as a neutral supplement to ecology. It is a hybrid observational regime that may document, intensify, or normalize certain forms of environmental interaction. Environmental ethics therefore requires that monitoring studies address not only data quality but the potential downstream consequences of visibility itself.

Environmental discourse, crisis communication, and governance

A third domain concerns public environmental discourse. Studies of Twitter/X, Weibo, and other social platforms reveal how environmental issues are framed, emotionally processed, and politically organized in digital publics (Dubey et al., 2024; Pimonenko et al., 2025; Salley et al., 2025; Liu et al., 2026). This literature contributes two important insights. First, environmental discourse is broader than climate discourse, but not evenly so. Climate change still dominates attention, while biodiversity loss or other planetary-boundary issues often remain peripheral, and discourse is disproportionately produced in the Global North (Dubey et al., 2024). Second, the emotional texture of environmental crises matters. Anxiety, sadness, and anger do not have identical triggers or policy implications, and rational communication by influential actors can moderate some forms of negative escalation (Liu et al., 2026).

These findings matter for environmental ethics because they illuminate the moral infrastructures of communication: visibility, attention, responsibility attribution, and the legitimacy of intervention. Disaster-management research similarly shows that social media can improve situational awareness and responsiveness, yet also suffer from serious problems of velocity, veracity, and quality (Abid et al., 2024). Flood-

communication studies reveal misalignments between organizational messages and community needs, pointing to the need for genuine two-way communication rather than extractive listening (Salley et al., 2025). Where environmental communication research once focused on message dissemination, it now increasingly concerns communicative justice—whose concerns count, whose emotions are legible, and which institutional voices can adapt in real time.

Sustainability governance, disclosure, and behavioral change

Beyond ecosystems and discourse, the literature also connects social media to broader sustainability governance. Studies examine ESG mapping, green-brand promotion, green travel, beach clean-up participation, sustainable consumption, corporate environmental disclosure, and consumer protection, showing that social media is part of the institutional environment through which sustainability priorities are defined and contested (Zhang & Xiang, 2024; Fildisi et al., 2025; Prastyanti & Srisuk, 2025; Yang et al., 2025). This strand broadens the field from observation to governance. Social media is not only a source of public data; it is also a channel through which norms are circulated, organizations are pressured, and behavior is incentivized.

The governance literature is especially relevant for environmental ethics because it foregrounds accountability, transparency, and normative design. New media surveillance can pressure heavy-polluting firms to disclose more environmental information, but it can also privilege attention dynamics over substantive responsibility (Zhang & Xiang, 2024). Green-brand studies show how positive ecological narratives are shaped by platform type and socio-political context rather than by environmental quality alone (Pimonenko et al., 2025). Sustainable consumer-protection scholarship highlights the need for ethical communication and regulation in influencer-driven digital markets (Prastyanti & Srisuk, 2025). Taken together, these studies show that digital sustainability governance is inseparable from communication ethics: credibility, fairness, transparency, and protection from manipulation are not optional add-ons but preconditions for legitimate environmental action.

Table 2. Methodological strengths and recurrent limitations in the reviewed literature

Data form	Analytical strength	Typical use	Recurring limitation	Preferred mitigation	Ref.
Geo-tagged images	Strong spatial specificity and visual richness	Landscape perception, scenic quality, species observation	Visual bias toward photogenic places/species	Pair with text, metadata, and field knowledge	Chen et al. (2024); Nascimento et al. (2024)
Text and reviews	Rich access to narratives, sentiment, and motives	CES mapping, crisis appraisal, park evaluation	Lexical ambiguity and platform-specific discourse norms	Context-aware NLP and manual validation	Comalada et al. (2025); Liu et al. (2026)
Multi-platform datasets	Greater coverage and cross-validation	Accessibility, visitation, environmental discourse	Heterogeneous user bases and inconsistent access	Platform comparison and transparent harmonization	Benati et al. (2024); Yang et al. (2025)
Passive citizen science feeds	Near-real-time ecological observations	Species monitoring and diver–wildlife interaction	Sensitive-location exposure and participation bias	Data safeguarding and selective disclosure	Otero et al. (2025); Fox et al. (2025)
Multimodal AI models	Better feature fusion and pattern detection	Park perception and biodiversity analytics	Reduced interpretability and higher privacy risk	Explainable AI and purpose limitation	Su et al. (2025); Chen et al. (2025)

Intervention-oriented NLP	Actionable insights for harmful discourse	Stance detection and messaging moderation	Normative overreach in automated intervention	Human oversight and explicit ethical criteria	Upadhyaya et al. (2025); Drumm & Tate (2026)

DISCUSSION

Why environmental ethics should organize the field

A striking feature of the literature is that the same concerns recur across otherwise disparate applications: representativeness, platform dependence, data access instability, privacy, unequal voice, interpretability, and context loss (Schirpke et al., 2023; Otero et al., 2025; Ghermandi et al., 2026). These concerns are typically presented as "limitations." Yet that framing understates their significance. When a platform over-represents tourists rather than residents, urban elites rather than marginalized communities, charismatic wildlife rather than obscure species, or visually attractive landscapes rather than mundane but ecologically important ones, the problem is not merely statistical. It is ethical because the resulting evidence may normalize whose environmental experiences matter and whose environments are worth managing for (Benati et al., 2024; Oguro & Shibata, 2025; Cao et al., 2026).

Environmental ethics offers a more adequate vocabulary. First, it highlights epistemic justice: who is represented in the production of environmental knowledge, and whose knowledge is discounted or rendered invisible. Recent studies explicitly show demographic bias in CES estimation, reduced women-performing users' nighttime uptake of green-space benefits, and systematic spatial inequities in access to cultural benefits (Calcagni et al., 2023; Oguro & Shibata, 2025; Benati et al., 2024; Cao et al., 2026). Second, environmental ethics foregrounds relationality. Many environmental benefits captured in social media are relational, affective, and place-bound rather than merely utilitarian or transactional (Degano et al., 2025; Li et al., 2026; Wang et al., 2026). Third, it clarifies that automation and intervention raise questions of responsibility and legitimacy, not just accuracy (Upadhyaya et al., 2025; Drumm & Tate, 2026).

Representation, demographic bias, and epistemic justice

The literature increasingly demonstrates that demographic and behavioral biases are not peripheral nuisances but constitutive features of digital trace data. Oguro and Shibata (2025) show that even when population-level demographics are known, platform activity itself varies systematically by age, sex, and place, affecting indicators such as georeferenced posting frequency. CES studies similarly show that locals and non-locals, residents and visitors, ordinary users and opinion leaders, or different gender performances can generate distinct value patterns (Calcagni et al., 2023; Li et al., 2026). Urban accessibility studies reveal that digital measurements of cultural benefits can align with, but also conceal, structural inequalities unless explicitly modeled as justice questions (Benati et al., 2024; Cao et al., 2026).

This has two implications. The first is methodological humility: social media data should rarely be treated as direct population proxies. The second is normative: researchers should specify whose environmental reality they are describing. A map of CES generated from TripAdvisor and Google Maps reviews is not simply a map of urban green-space value; it is a map of value expressed by particular platform publics under particular communicative conditions (Cao et al., 2026). An ethically mature field should therefore make representational scope explicit in article titles, methods, and policy claims, rather than burying it in limitations paragraphs.

Privacy, consent, and the ethics of digitally mediated observation

Privacy and consent have moved to the center of the field. General reviews of online social-network ethics emphasize data

vulnerability, adaptive privacy needs, and the need for privacy-protective design as AI intensifies content classification and moderation (Chandana et al., 2025). In environmental research, the privacy problem is sharpened by context. Posts about parks, forests, diving sites, wildlife, or local environmental crises are often highly place specific. Even when technically public, they may reveal movement patterns, sensitive ecological locations, or emotionally vulnerable situations. Biodiversity scholars explicitly warn that AI and open-source tools can make citizen-sourced data easier to exploit in harmful ways (Fox et al., 2025). Passive citizen-science researchers likewise note that social media landscapes are shifting rapidly and that democratizing access must be balanced with governance safeguards (Otero et al., 2025).

The ethical issue here is not resolved by de-identification alone. Environmental content is often relationally identifiable: a location, species, event, or community may be inferable even if usernames are removed. Moreover, the moral legitimacy of using content for research or management cannot be reduced to legal availability. Environmental ethics suggests a stronger standard: context-sensitive respect for persons, communities, and ecological subjects. This includes minimizing unnecessary extraction, avoiding publication of sensitive details, and articulating clear public-interest justifications for data use, especially where management actions or interventions may follow (Fox et al., 2025; Chandana et al., 2025; Prastyanti & Srisuk, 2025).

Responsible automation, interpretability, and intervention

The field's increasing reliance on AI also raises distinctly ethical concerns. Explainable machine learning and interpretable stance detection are promising because they make model outputs more contestable and actionable (Chen et al., 2024; Upadhyaya et al., 2025). Yet interpretable systems can still embed normative assumptions about what counts as harm, civility, positive emotion, or ecologically desirable behavior. Intervention-oriented systems that aim to reduce offensive content or simulate responses to environmental messaging move researchers closer to public behavioral steering (Upadhyaya et al., 2025; Drumm & Tate, 2026). This may be justified in some cases, but only if the ethical basis of intervention is explicit, deliberative, and accountable.

Environmental ethics also demands caution regarding the translation of sentiment into policy. Studies linking heat to negative sentiment, environmental crises to emotional dynamics, or indoor health perceptions to digital discourse show that social media can reveal important aspects of well-being and justice (Ashayeri, 2024; Aromí et al., 2025; Liu et al., 2026). But public feeling is not equivalent to public interest, and digitally expressed affect is shaped by platform incentives, outrage dynamics, and selective participation. Responsible automation must therefore combine interpretability with triangulation: model outputs should be checked against theory, qualitative context, and, where feasible, complementary offline methods (Dagan & Wilkins, 2023; Schirpke et al., 2023; Yang et al., 2025).

Environmental justice and the distribution of digital visibility

Environmental ethics ultimately converges with environmental justice. Studies of urban green spaces, energy justice, climate migration, beach clean-up participation, and sustainable infrastructure all indicate that digital environmental data can either illuminate or reproduce unequal distributions of exposure, voice, and benefit (Ashayeri & Abbasabadi, 2024; Cattaneo et al., 2026; Cao et al., 2026). Justice in this literature is not limited to access to ecosystems; it also includes access to participation in environmental discourse and to the infrastructures through which environmental problems become visible and governable. A socially media-rich park may receive more managerial attention than an equally needed

but digitally silent one. A charismatic species may attract more conservation response than an equally threatened but less photogenic one. A platform-active constituency may appear more "engaged" than communities with weaker digital access.

This suggests that digital visibility is itself an environmental good unevenly distributed across places and populations. Future research should therefore distinguish between ecological value, socially expressed value, and algorithmically amplified value. These are related but not interchangeable. An environmental-ethics framework helps keep those distinctions visible and prevents researchers from mistaking platform salience for moral priority.

Table 3. An environmental-ethics agenda for future research and practice

Ethical principle	Research implication	Design recommendation	Policy relevance	Illustrative literature	Ref.
Epistemic justice	Specify whose experiences the data represent	Report user/public scope and missing publics explicitly	Avoid overgeneralizing from platform users to populations	CES bias and access studies	Oguro & Shibata (2025); Benati et al. (2024); Cao et al. (2026)
Relational valuation	Preserve plural, context-specific environmental meanings	Combine standardized categories with inductive coding	Prevent reduction of non-material values to narrow metrics	CES and NCP studies	Degano et al. (2025); Li et al. (2026); Wang et al. (2026)
Privacy and care	Treat public content as context-bound, not free-for-all data	Use minimization, selective disclosure, and sensitivity review	Protect users, places, and species from exposure harms	Social-network and biodiversity ethics	Chandana et al. (2025); Fox et al. (2025)
Responsible automation	Make models contestable and interpretable	Pair explainable AI with human oversight	Reduce opaque policy translation from model output	Explainable and intervention-oriented systems	Upadhyaya et al. (2025); Chen et al. (2025)
Procedural justice	Align analytics with community needs, not only institutional goals	Incorporate two-way communication and stakeholder validation	Improve legitimacy of crisis and environmental governance	Disaster and discourse studies	Abid et al. (2024); Salley et al. (2025)
Ecological prudence	Anticipate harms caused by visibility and popularity signals	Assess whether publishing findings can intensify pressure	Support conservation without exposing sensitive ecologies	Passive citizen science and marine monitoring	Otero et al. (2025); Neri et al. (2026)

A research agenda for the next generation of review and empirical work

The first priority is conceptual clarity. The newest CES synthesis makes clear that researchers still conflate ecosystem services, benefits, values, and user-expressed experiences (Ghermandi et al., 2026). Similar slippages appear across sustainability and communication research, where engagement, sentiment, awareness, behavior change, and governance influence are sometimes treated as equivalent outcomes (Singh et al., 2025; Purushottam & Matli, 2025). Future studies should state more precisely whether they are measuring environmental experience, discourse about the environment, behavioral intention, reputational signaling, or policy-relevant public response. Environmental ethics is helpful here because it demands conceptual

honesty about what is being claimed on behalf of the data.

The second priority is multimethod triangulation. The literature repeatedly recommends pairing social media with surveys, expert knowledge, geospatial indicators, or other big-data streams, yet many empirical studies still rely on one platform or one modality (Schirpke et al., 2023; Dagan & Wilkins, 2023; Yang et al., 2025; Ghermandi et al., 2026). Triangulation is not simply a technical fix for bias. It is an ethical commitment to avoiding overreach. If management decisions, restoration priorities, or communication strategies are informed by social media analytics, then the evidence base should be proportionate to the stakes of the decision. Combining multiple sources can also help distinguish platform artifacts from more robust environmental patterns.

The third priority is governance-ready transparency. Environmental researchers increasingly speak to planners, conservation managers, firms, and policymakers. That audience requires more than impressive model performance. It requires transparent explanation of data provenance, platform limitations, preprocessing choices, annotation assumptions, and uncertainty ranges (Abid et al., 2024; Fildisi et al., 2025; Upadhyaya et al., 2025). Governance-ready transparency also means documenting what the model cannot see: offline communities, non-posting visitors, species and places that are under-photographed, or issue publics marginalized by language and access barriers (Otero et al., 2025; Yang et al., 2025; Ghermandi et al., 2026).

The fourth priority is comparative and Global South research. Several reviews note that environmental discourse, CES analysis, and platform access remain unevenly distributed geographically (Dubey et al., 2024; Yang et al., 2025; Su et al., 2025). Context-sensitive comparison is urgently needed because identical methods can yield very different meanings across regulatory systems, linguistic communities, ecological settings, and media cultures. Without such work, the field risks universalizing categories and interventions derived disproportionately from high-income, platform-rich, and English-dominant contexts.

The fifth priority is explicit ethical review tailored to environmental digital research. General data-ethics principles are necessary but insufficient. This field needs protocols attentive to ecologically sensitive locations, vulnerable publics, algorithmic classification of environmental attitudes, and the use of outputs in consequential governance contexts. The ethical problem in a study of urban-park reviews is different from that in a study of endangered species sightings, climate-migration discourse, or online intervention into environmental conflict (Fox et al., 2025; Cattaneo et al., 2026; Upadhyaya et al., 2025). A top-tier research agenda should therefore move toward domain-specific ethics review templates for environmental digital methods.

Finally, the field should embrace environmental ethics as a theory-generating resource, not merely a checklist. Ethics can help explain why some values are digitally expressive while others remain tacit; why some environmental harms trigger outrage while others elicit resignation; why some species or places become iconic; and why some communicative interventions are perceived as legitimate while others are not. Integrating environmental ethics with computational methods could produce more ambitious accounts of how care, justice, identity, and responsibility are enacted in digital environmental publics (Spaiser, 2025; Singh et al., 2025; Ghermandi et al., 2026).

CONCLUSION

The reviewed literature shows that social media has become a powerful but deeply non-neutral infrastructure for environmental research. Across CES, biodiversity monitoring, environmental communication, sustainability governance, and justice-oriented planning, digital traces provide unprecedented opportunities to study how environments are perceived, valued, narrated, and contested (Schirpke et al., 2023; Singh et al., 2025; Ghermandi et al.,

2026). Yet these same studies demonstrate that scale and novelty do not eliminate the need for interpretation; they intensify it. Platform publics are partial publics. Algorithmic classifications are situated judgments. Digital visibility is unevenly distributed. And research outputs increasingly shape management, disclosure, communication, and conservation decisions.

The strongest contribution of the recent literature is therefore not only methodological sophistication. It is the recognition—sometimes explicit, sometimes implicit—that environmental research with social media data is a normative practice. It involves choices about which experiences count, which risks can be tolerated, which data can be used, and what kinds of interventions are justified. Environmental ethics offers the field a way to treat those choices systematically. By centering epistemic justice, relational values, privacy and care, responsible automation, and ecological prudence, researchers can build a more reflexive and policy-relevant science of digital environmental life.

A mature field will not be the one with the largest scraped dataset or the most complex multimodal model. It will be the one that can explain, justify, and, when necessary, limit its own claims in the service of ecologically sound and socially just decision making. In that sense, environmental ethics is not adjacent to the future of social media–based sustainability research. It is the condition of its legitimacy.

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REFERENCES

1. S. Abid, B. K. Mishra, U. Younis, D. Thakker, and N. Mishra, "Social Media Data: Challenges, Mitigation Strategies, and Opportunities for Disaster Management," Proceedings of the 2024 International Conference on Frontiers of Information Technology, FIT 2024, doi: 10.1109/FIT63703.2024.10838417.
2. J. D. Aromí, M. Conte Grand, M. Rabassa, and J. Rozenberg, "Impact of temperature on expressed sentiments in social media: Evidence from a Latin American country," Environment and Development Economics, doi: 10.1017/S1355770X24000342.
3. M. Ashayeri and N. Abbasabadi, "Unraveling energy justice in NYC urban buildings through social media sentiment analysis and transformer deep learning," Energy and Buildings, 306, 113914, doi: 10.1016/j.enbuild.2024.113914.
4. M. Ashayeri, "Decoding Global Indoor Health Perception on Social Media Through NLP and Transformer Deep Learning," Artificial Intelligence in Performance-Driven Design: Theories, Methods, and Tools, 159-185, doi: 10.1002/9781394172092.ch8.
5. G. Benati, F. Calcagni, F. Matellozzo, A. Ghermandi, and J. Langemeyer, "Unequal access to cultural ecosystem services of green spaces within the city of Rome – A spatial social media-based analysis," Ecosystem Services, 66, 101594, doi: 10.1016/j.ecoser.2023.101594.
6. F. Calcagni, J. J. T. Connolly, and J. Langemeyer, "Plural relational green space values for whom, when, and where? – A social media approach," Digital Geography and Society, 5, 100065, doi: 10.1016/j.diggeo.2023.100065.
7. H. Cao, H. Zhao, C. T. Callaghan, and J. Qiu, "Unequal access to cultural ecosystem services across urban greenspaces," Landscape and Urban Planning, 271, 105635, doi: 10.1016/j.landurbplan.2026.105635.
8. C. Cattaneo, S. Shayegh, C. Albert, M. Alsina-Pujols, H. Benveniste, M. Borderon, B. Conte, C. Deuster, J. S. Görlach, T. Haer, R. Hoffmann, R. Muttarak, M. Ronco, J. Schewe, and A. Wiśniowski, "Broadening climate migration research across impacts, adaptation and mitigation," Nature Climate Change, 16(3), 255-260, doi: 10.1038/s41558-025-02545-1.
9. A. Chai-allah, N. Fox, F. Günther, F. Bentayeb, G. Brunschwig, S. Bimonte, and F. Joly, "Mining crowdsourced text to capture hikers' perceptions associated with landscape features and outdoor physical

activities," Ecological Informatics, 78, 102332, doi: 10.1016/j.ecoinf.2023.102332.
10. D. M. Chandana, M. R. Sankalp, S. Kathavate, and S. Aruna, "Inspection of Ethical and Privacy Concerns in Online Social Networks," Proceedings of 2025 International Conference on Computing for Sustainability and Intelligent Future, COMP-SIF 2025, doi: 10.1109/COMP-SIF65618.2025.10969903.
11. K. Chen, T. Xia, Z. Cao, Y. Li, X. Lin, and R. Bai, "Predictive Models for Environmental Perception in Multi-Type Parks and Their Generalization Ability: Integrating Pre-Training and Reinforcement Learning," Buildings, 15(13), 2364, doi: 10.3390/buildings15132364.
12. Z. Chen, H. Yang, Y. Lin, J. Xie, Y. Xie, and Z. Ding, "Exploring the association between the built environment and positive sentiments of tourists in traditional villages in Fuzhou, China," Ecological Informatics, 80, 102465, doi: 10.1016/j.ecoinf.2024.102465.
13. Z. Chen, C. Ye, H. Yang, P. Ye, Y. Xie, and Z. Ding, "Exploring the impact of seasonal forest landscapes on tourist emotions using Machine learning," Ecological Indicators, 163, 112115, doi: 10.1016/j.ecolind.2024.112115.
14. F. Comalada, O. Llorente, V. Acuña, J. Saló, and X. Garcia, "Using georeferenced text from social media to map the cultural ecosystem services of freshwater ecosystems," Ecosystem Services, 72, 101702, doi: 10.1016/j.ecoser.2025.101702.
15. D. T. Dagan and E. J. Wilkins, "What is “big data” and how should we use it? The role of large datasets, secondary data, and associated analysis techniques in outdoor recreation research," Journal of Outdoor Recreation and Tourism, 44, 100668, doi: 10.1016/j.jort.2023.100668.
16. M. E. Degano, S. Augustino Kwaslema, K. Böhning-Gaese, A. Hemp, L. Lehnen, B. Martín-López, J. Pearson, T. Mueller, and U. Arbieu, "Perceptions of nature and its non-material contributions to people at Mount Kilimanjaro," People and Nature, 7(7), 1697-1712, doi: 10.1002/pan3.70079.
17. Y. Depietri, A. Ghermandi, L. Hadar, and D. E. Orenstein, "Leveraging AI and social media for actionable insights for nature park management," Journal of Outdoor Recreation and Tourism, 52, 100923, doi: 10.1016/j.jort.2025.100923.
18. Y. Depietri, J. Langemeyer, D. V. Berkel, and A. Ghermandi, "Advancing sustainability research through geospatial technology and social media," The Routledge Handbook of Geospatial Technologies and Society, 494-504.
19. M. M. Derrien, S. G. Winder, S. A. Wood, L. Miller, E. H. Lia, L. K. Cerveny, S. Lange, S. H. Kolstoe, G. McGrady, and A. Roth, "Where wilderness is found: Evidence from 70,000 trip reports," People and Nature, 6(1), 202-219, doi: 10.1002/pan3.10569.
20. J. Ding, W. Yu, Y. Mao, Z. Tao, D. Chen, and L. Wang, "Rethinking the landscape perception of traditional built environment from the perspective of depth," Frontiers of Architectural Research, doi: 10.1016/j.foar.2025.08.004.
21. I. Drumm and A. Tate, "Simulating human responses to environmental messaging," Journal of Computational Social Science, 9(1), 23, doi: 10.1007/s42001-025-00453-0.
22. S. Dubey, M. H. C. Meijers, E. S. Smit, and E. G. Smit, "Beyond climate change? Environmental discourse on the planetary boundaries in Twitter networks," Climatic Change, 177(5), 73, doi: 10.1007/s10584-024-03729-y.
23. B. Fildisi, E. Vakaj, A. Dridi, A. S. Imran, and R. M. A. Azad, "Integrating AI-driven analytics for enhanced ESG mapping: Aligning local and global perspectives," Sustainable Futures, 10, 101231, doi: 10.1016/j.sftr.2025.101231.
24. N. Fox, E. Di Minin, N. Carter, S. Tomkins, and D. Van Berkel, "Balancing accessibility and security: Safeguarding citizen-sourced biodiversity data in the age of AI and open-sourced software," Ecological Informatics, 92, 103443, doi: 10.1016/j.ecoinf.2025.103443.
25. A. Ghermandi and M. Sinclair, "Monetary Values of the Non-Market Benefits of Estuarine and Coastal Cultural Ecosystem Services," Treatise on Estuarine and Coastal Science, Second Edition: Seven Volume Set, Vol7:154-Vol7:165, doi: 10.1016/B978-0-323-90798-9.00105-0.
26. A. Ghermandi, F. Calcagni, J. Langemeyer, and U. Schirpke, "Digital windows into nature's values: A critical review of cultural ecosystem services research with social

media data," Ecosystem Services, 79, 101839, doi: 10.1016/j.ecoser.2026.101839.
27. A. Ghermandi, Y. Depietri, and D. E. Orenstein, "Human-nature interactions through a digital prism: Heterogeneity in user socio-demographics and content across social media platforms," Landscape and Urban Planning, 268, 105568, doi: 10.1016/j.landurbplan.2025.105568.
28. S. B. Hunter, M. Oedin, J. Weeds, and F. Mathews, "Exploring the potential for online data sources to enhance species threat mapping through the case study of global bat exploitation," Conservation Biology, 38(4), e14242, doi: 10.1111/cobi.14242.
29. V. H. Klaus, F. J. Richter, N. Fox, D. Andreatta, and A. Chai-allah, "Powerful flowers: Public perception of grassland aesthetics is strongly related to management and biodiversity," Agriculture, Ecosystems and Environment, 398, 110111, doi: 10.1016/j.agee.2025.110111.
30. Q. Li, Y. Lou, C. Liu, M. Yang, M. He, and P. Cao, "Dynamics of Cultural Ecosystem Services in rural landscape: a social media analysis," Tourism Geographies, 28(2), 260-284, doi: 10.1080/14616688.2025.2597505.
31. J. Liu, D. Lou, and C. Fu, "Negative Emotional Responses on Social Media During Crisis Events," Journal of Contingencies and Crisis Management, 34(1), e70131, doi: 10.1111/1468-5973.70131.
32. P. V. Mole and E. B. Noche, "Human Sensing and Social Media Data for Monitoring the Environment in Baguio City," AIP Conference Proceedings, 3287(1), 030011, doi: 10.1063/5.0269522.
33. L. S. Nascimento, M. N. Júnior, C. S. Hara, and M. A. Noernberg, "Passive citizen science: social media as a tool for marine wildlife observation," Marine Ecology Progress Series, 740, 219-233, doi: 10.3354/meps14629.
34. L. S. Nascimento, M. A. Noernberg, T. B. Bleninger, A. Lindner, and M. Nogueira Júnior, "Not such a rare species, after all? Insights into Drymonema gorgo Müller 1883 (Cnidaria, Scyphozoa), a large and little-known jellyfish from Brazil," Aquatic Ecology, 58(1), 17-30, doi: 10.1007/s10452-023-10074-2.
35. R. Neri, A. Oren, U. Roll, and N. Shashar, "Using social media to monitor diving pressure and diver-wildlife interactions in the northern Red Sea," Coral Reefs, 45(1), 181-197, doi: 10.1007/s00338-025-02713-x.
36. M. Oguro and R. Shibata, "Quantifying effects of demographic biases on estimation of cultural ecosystem services using social media in Japan," Ecosystem Services, 76, 101777, doi: 10.1016/j.ecoser.2025.101777.
37. P. Otero, J. Menéndez-Blázquez, and D. March, "Challenges of passive citizen science in ecology within a shifting social media landscape," Ecological Informatics, 90, 103278, doi: 10.1016/j.ecoinf.2025.103278.
38. T. Pimonenko, O. Lyulyov, and Y. Us, "Country Green Brand Promotion: A Sentiment Analysis," Forum Scientiae Oeconomia, 13(2), 27-51, doi: 10.23762/FSO_VOL13_NO2_2.
39. R. A. Prastyanti and P. Srisuk, "Achieving Sustainable Consumer Protection in the Era of Social Media," Journal of Sustainable Development and Regulatory Issues, 3(1), 121-146, doi: 10.53955/jsderi. v3i1.52.
40. N. Purushottam and W. Matli, "Social Media and Sustainable Consumption: Setting Research Agenda," Smart Innovation, Systems and Technologies, 393, 675-684, doi: 10.1007/978-981-97-3698-0_44.
41. C. Salley, N. Fox, and A. Schubert, "Bridging the gap in flood risk communication: a comparative study of community and organizational social media posts using natural language processing," Frontiers in Communication, 10, 1553746, doi: 10.3389/fcomm.2025.1553746.
42. U. Schirpke, A. Ghermandi, M. Sinclair, D. Van Berkel, N. Fox, L. Vargas, and L. Willemen, "Emerging technologies for assessing ecosystem services: A synthesis of opportunities and challenges," Ecosystem Services, 63, 101558, doi: 10.1016/j.ecoser.2023.101558.
43. S. S. Singh, S. Kumar, A. Kishor, and A. Y. Zomaya, "Advancing Sustainability Through Social Media: A Comprehensive Survey," IEEE Transactions on Sustainable Computing, 10(6), 1128-1146, doi: 10.1109/TSUSC.2025.3591527.
44. V. Spaiser, "Computational social science approaches to sustainability and climate change," Handbook of Computational Social Science, 372-383, doi: 10.4337/9781802207309.00041.
45. P. Su, Y. Yan, H. Li, H. Wu, C. Liu, and W. Huang, "Images and deep learning in human

and urban infrastructure interactions pertinent to sustainable urban studies: Review and perspective," International Journal of Applied Earth Observation and Geoinformation, 136, 104352, doi: 10.1016/j.jag.2024.104352.
46. A. Upadhyaya, W. Nejdl, and M. Fisichella, "Interpretable zero-shot stance detection with proactive content intervention," Information Processing and Management, 62(6), 104223, doi: 10.1016/j.ipm.2025.104223.
47. Y. Wang, K. Vierikko, J. Langemeyer, J. Lehtimäki, and D. Johan Kotze, "Visitor perceptions and motivations as drivers of cultural ecosystem services in urban forests: A case study from Helsinki, Finland," Ecosystem Services, 78, 101817, doi: 10.1016/j.ecoser.2026.101817.
48. Q. Yang, B. Zhang, J. Chen, Y. Song, and X. Shen, "Integrating crowdsourced data in the built environment studies: A systematic review," Journal of Environmental Management, 373, 123936, doi: 10.1016/j.jenvman.2024.123936.
49. E. Zarrabeitia-Bilbao, M. Jaca-Madariaga, R. M. Rio-Belver, and I. Alvarez-Meaza, "From Sustainable Development Goals to sustainable industry, innovation and infrastructure: insights from the digital sphere," Environment, Development and Sustainability, 27(4), 9407-9425, doi: 10.1007/s10668-023-04288-5.
50. Q. Zhang and Z. Xiang, "New media surveillance, environmental information uncertainty and corporate environmental information disclosure," International Review of Economics and Finance, 95, 103477, doi: 10.1016/j.iref.2024.103477.

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